Differentiation of Seed Germination and Early Seedling Growth in Ten Provenances of *Eucalyptus Microtheca*

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ABSTRACT An investigation of seed germination and early seedling growth of *Eucalyptus microtheca* was based on seed collection from 10 widely separated provenances in Australia. Genetic variation of seed germination and early seedling growth was observed among a series of provenances whose natural habitats range from different climatic condition. In the ten provenances, both the model of seed relative germination percentage and the model of seed total germination percentage fitted Logistic regression [y=a/(1+exp(-cx+b))]. In comparison with provenances from four high temperature (mean annual maximum temperature >30.0 °C; mean annual minimum temperature >17.0 °C) areas, six low temperature (mean annual maximum temperature <30 °C; mean annual minimum temperature <17.0 °C) areas showed the fast germination rate and the high total germination percentage. For each provenance we have 45 seedlings equally divided into three watering levels (100%, 50%, and 25% of field capacity), and studies on relationship between early seedling growth and climatic factors of the natural habitat of provenance. In control treatment, height growth of the seedling has been associated with intrinsically the driest quarter precipitation in the seed collection areas of provenance. In all the treatments, length growth of the biggest leaf of the seedling was related to mean annual maximum temperature and mean annual minimum temperature in origin of provenance. In contrast, basal diameter growth of the seedling was related to mean annual minimum temperature of the seed collection areas in water stress treatment. From an ecological viewpoint, the fast germination rate and the high total germination percentage of the seed and rapid early growth of the seedling appear to be favourable adaptations to the climatic conditions prevailing in the natural habitat of provenance.

Key words: Early seedling growth; Eucalyptus microtheca; Provenance variation; Seed germination

INTRODUCTION

Eucalyptus microtheca F. Muell. (coolibah) has a wide geographic range mainly within the arid and semi-arid zones of Australia (Boland et al. 1984). The range of latitude is 14-33 S with an altitudinal range of just above sea level to 700 m. There is less variation in climate than might be expected from the wide range of latitude. Away from the immediate effects of the sea, conditions are continental with very hot summers and mild winters. The mean maximum temperature of the hottest month is in the range of 31-41 C while the mean minimum of the coolest is 4-14 C. In the northern parts of Western Australia, Northern Territory and Queensland there is a well developed monsoonal rainfall pattern; elsewhere there is a summer maximum but changing to a more even distribution towards the southeast. The long-term rainfall patterns are often overshadowed by the high variability from year to year.

In eucalyptus, seed germination tests are usually conducted under controlled conditions of temperature, light and moisture and, of these, seed has been found to be quite sensitive to temperature (Akhtar 1973). In determining the fast germination rate and the high total germination percentage, it is desirable to distinguish between genetic and environmental effects. The conditions under which the seed has developed to maturation and the storage conditions prior to testing can influence the germination response.

For tropical tree species in arid and semi-arid zones, growth of the tree can be associated much more readily with water stress where a distinct, albeit short, dry season develops than in regions with more or less sufficient water supply throughout the growing season. It is not surprising that many studies have been made of this association between environment and plant response (Bachelard 1986a, 1986b; Berry et al 1980; Dickmann 1992; Ladiges 1975; Myers et al 1989; Passioura 1982), but the detail in such studies is commonly less than is reported for many investigations on temperate zone species (Doley 1981). Species with a wide diversity of habitats are often composed of ecotypes, each of which is adapted to prevailing conditions (Gibson et al. 1990, 1991). However, physiological and morphological adap-

tion mechanisms have been studied relatively little for intra-specific comparison, especially, study on differentiation in some provenances of *Eucalyptus* in relation to climatic factors of the natural habitat affecting seed germination and early seedling growth.

The aim of this study was to probe mechanism of seed germination and early seedling growth in ten provenances of *Eucalyptus microtheca*, which may be used for selection of suitable provenances of *E. microtheca* for different environmental conditions. For this purpose, the study focused on investigating seed germination rate and seed total germination percentage, height and basal diameter growth of the seedling, width and length growth of the biggest leaf of the seedling, and relation to climatic factors of the seed collection areas affecting seed germination and early seedling growth.

MATERIAL AND METHODS

Ten provenances (Table 1, 2) of *E. microtheca*, were selected for the study, which were being used in an irrigated provenance trial in eastern Kenya (Tuomela et al. 1993; Johansson et al. 1996).

Table 1. Origin of ten provenances of *E. microtheca* used in the study

Seedlot	Parent trees	Locality	Latitude		Longitude		Alt
			Deg	Min	Deg	Min	(m)
15070	8	Hamersleys/Pilbara(WA)	22	40	118	05	550
15073	8	West Kimberleys(WA)	18	00	125	00	110
15074	10	Newcastle Waters(NT)	17	00	134	45	160
15075	11	Camooweal(NT)	19	40	135	15	360
15076	16	Central Austral.(NT)	24	30	132	50	490
15077	20	Maree/Oodnadatta(SA)	28	30	136	40	65
15081	20	South West Qld(QLD)	27	20	144	35	180
15084	15	Walgett/Mungindi(NSW)	29	20	148	35	155
15085	8	Western NSW(NSW)	32	05	142	45	80
15944	10	Rockhampton(QLD)	23	22	150	31	4

Table 2. The climatic factors of origin of ten provenances of *E. Microtheca* used in the study *

Seed lot	Rainfall (mm)	Driestquarter precipitation	Maximum temperature	Minimum temperature	Number of rainy days
15070	394	24	32.7	19.6	41
15073	517	10	36.0	19.2	45
15074	494	8	34.2	19.5	47
15075	380	14	33.2	17.8	36
15076	263	27	28.7	13.8	35
15077	196	54	28.6	13.0	36
15081	360	57	28.2	14.3	43
15084	469	86	27.2	12.4	54
15085	233	52	23.7	12.0	38
15944	961	93	28.2	16.2	88

* These climatic factors are mean annual values by many years.

In Helsinki, Finland, for each provenance 250 seeds were divided into five groups, and each group 50 seeds were sown on wet tissue paper in Petri dishes on 25 April 1995. The dishes were kept in a plexiglass chamber where a minimum temperature of 28 C was maintained. After germination, between 28 April and 7 May, the seeds were pricked into to small plastic pots and grown for about a month. The pots were watered continuously.

A second transplanting was done on 6 June to pots with 2 litres of volume. A commercial peat-sand mixture, Kekkilan viljelyturve, was used as growth medium in the seedling pots. One cubic metre substrate contained 0.7 kg fertilizer (10% N, 8% P and 16% K) and 8 kg Mg-rich limestone power. The substrate was packed into the seedling pot with a density of about 0.4 g/cm^3. The seedlings grew in a semi-controlled environment in a greenhouse where the minimum temperature was set at 17 C. The daily temperature was allowed to fluctuate according to weather conditions.

The 2-litre pots were thoroughly watered and kept in a basin partly with water overnight to let them reach field capacity before the second transplanting. The pots were assumed to be at field capacity and weighed after they were removed from the water basin and allowed to drain. The seedlings were fertilized with a commercial(Kekkila Superex-10; 7% N, 5% p, 26% K) in 0.3% solution twice during the experiment. Pesticides (Aplaudd, Pirimor and Vertimec) and fungicides(Benlate and Saprol) were used when necessary.

The experiment was laid out in a completely randomised design with two factors (ten provenances and three watering levels). For each provenance there 45 seedlings equally divided into three watering levels; i.e. control treatment (100% of field capacity), and water stress treatments (50% of field capacity and 25% of field capacity).

A two-day cyclical watering schedule was applied

throughout the experiment. The water loss was estimated every second day by weighing five randomly selected pots from the control treatment. This measured water loss was completely compensated in the control treatment. The stress treatments were induced as follows: in the two stress treatments, only 50% or 25% of the measured water loss was compensated as compared with the control treatment. To avoid systematic error due to possible differences in light conditions, the seedlings were rotated twice during the experiment. Temperature and relative humidity were recorded daily at 14:00 h local time.

Height, basal diameter, width and length of the biggest leaf of each seedling in three watering levels were measured at end of experiment (11 October, 1995).

Data were analysed using the analysis of variance. Tukey's test was used to detect possible differences between the provenances. Statistical analyses were done with a SYSTAT statistical software package.

RESULTS

Seed Germinatiom In ten provances, both the model of seed relative germination percentage and the model of seed total germination percentage fitted Logistic regression ($y=a/(1+\exp(-cx+b))$) (Fig. 1 and 2; Table 3 and 4).

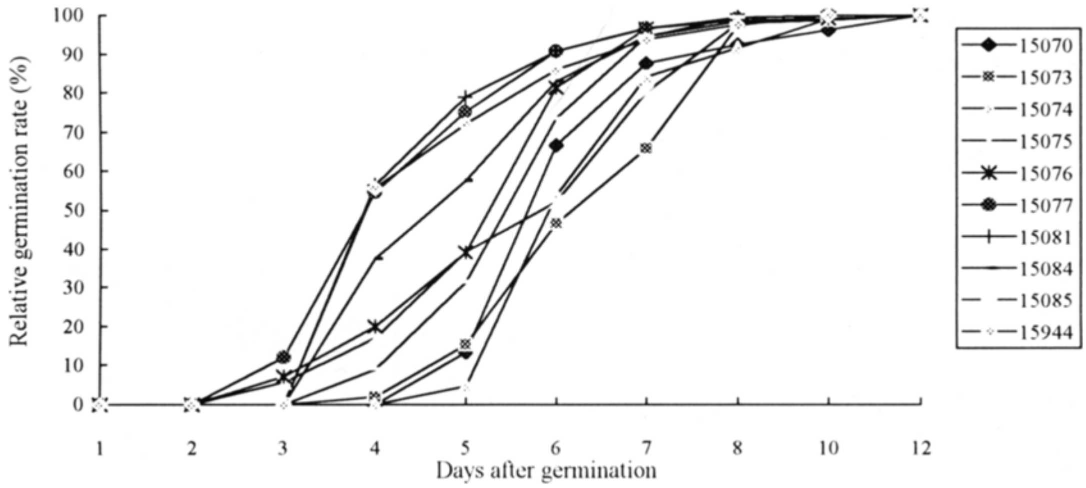

Fig. 1 Relative germination percentage of seeds for ten provenances of *E. microtheeca*

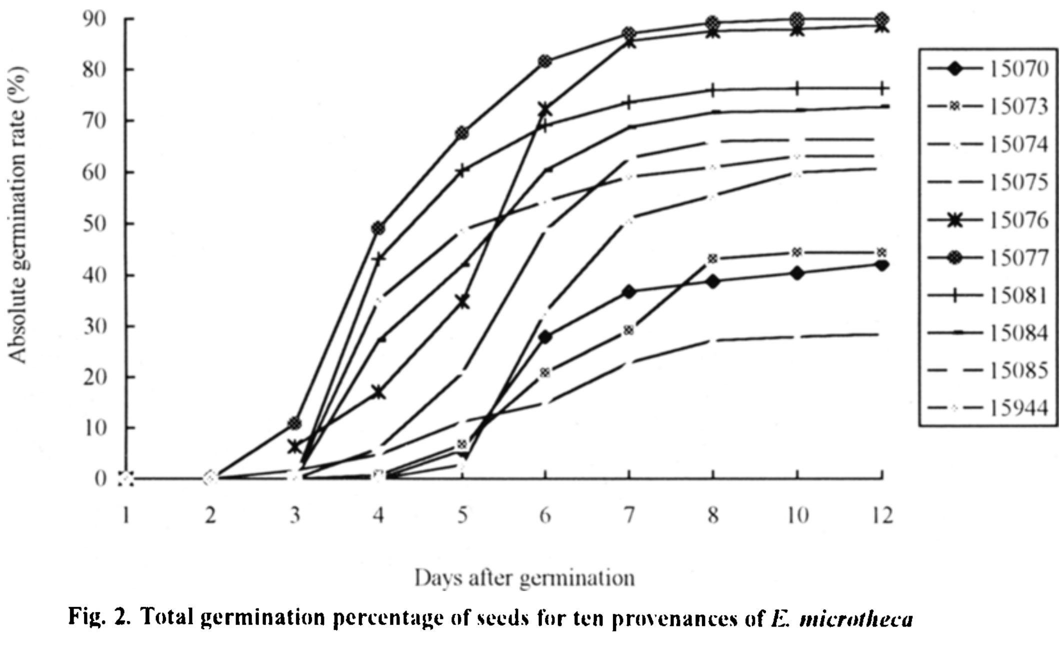

Fig. 2. Total germination percentage of seeds for ten provenances of *E. microtheca*

Table 3. The model of seed relative germination percentage

Seedlot No.	Model	R	P	T
15070	y = 1/(1+ exp(-0.748x + 4.236))	0.812	0.031	9.5991
15073	y = 1/(1+ exp(-1.753x +10.840))	0.898	0.002	7.8628
15074	y = 1/(1+ exp(-1.101x +7.048))	0.817	0.026	9.0758
15075	y = 1/(1+ exp(-0.943x +5.257))	0.917	0.001	8.6972
15076	y = 1/(1+ exp(-1.004x +4.971))	0.873	0.002	7.8839
15077	y = 1/(1+ exp(-1.268x +5.358))	0.894	0.001	6.5477
15081	y = 1/(1+ exp(-1.192x +4.678))	0.885	0.002	6.3947
15084	y = 1/(1+ exp(-0.764x +3.088))	0.859	0.006	7.8960
15085	y = 1/(1+ exp(-1.848x +9.910))	0.932	0.001	6.9559
15944	y = 1/(1+ exp(-0.858x +3.280))	0.923	0.001	7.2546

* y is seed relative germination percentage(%); x is time after germination (days). T is time when seed relative germination percentage gets 95% (days).

Studies on Relationship between Time of Getting 95% Relative germination percentage (T) or seed total germination percentage (Y) and climatic factors of the natural habitat of provenance (Table 5, 6) show that T and Y has been associated with intrinsically mean annual maximum temperature and mean annual minimum temperature in the seed collection areas of provenance in Australia.

Table 4. The model of seed total germination percentage

Seedlot No.	Model	R	P	K
15070	y = 1/(1+ exp(-0.242x + 2.887))	0.766	0.032	42.2
15073	y = 1/(1+ exp(-0.459x +4.948))	0.806	0.028	44.4
15074	y = 1/(1+ exp(-0.400x +3.790))	0.794	0.034	60.8
15075	y = 1/(1+ exp(-0.305x +4.007))	0.847	0.008	28.4
15076	y = 1/(1+ exp(-0.500x +3.018))	0.860	0.006	88.8
15077	y = 1/(1+ exp(-0.381x +1.608))	0.810	0.015	90.0
15081	y = 1/(1+ exp(-0.144x +0.310))	0.800	0.031	76.4
15084	y = 1/(1+ exp(-0.209x +1.188))	0.818	0.025	72.8
15085	y = 1/(1+ exp(-0.348x +2.860))	0.781	0.028	66.4
15944	y = 1/(1+ exp(-0.117x +0.677))	0.832	0.001	63.2

* y is seed total germination percentage(%); x is time after germination (days). K is seed total germination percentage when x is 12 days (at end of the germination experiment).

In addition, there was a tendency of significant relationship between T and the driest quarter precipitation in origin of provenance.

Table 5. Relationship between time of getting 95% relative germination percentage and climatic factors of origin of provenance

Climatic factors	Model	R	P
Rainfall(mm)	T = 7.580 + 0.001 x	0.113	0.756
The driest quarter precipitation(mm)	T = 8.677 - 0.020 x	0.584	0.076
Maximum temperature(C)	T = 2.292 + 0.184 x	0.651	0.041 *
Minimum temperature(C)	T = 3.741 + 0.258 x	0.739	0.015 *
Number of rainy days	T = 8.154 - 0.007 x	0.108	0.767

Table 6. Relationship between seed total germination percentage and climatic factors of origin of provenance

Climatic factors	Model	R	P
Rainfall(mm)	Y = 74.394 - 0.026 x	0.279	0.435
The driest quarter precipitation(mm)	Y = 50.241 + 0.308 x	0.470	0.170
Maximum temperature(C)	Y =164.360 - 3.359 x	0.639	0.048 *
Minimum temperature(C)	Y =140.986 - 4.921 x	0.745	0.013 *
Number of rainy days	Y = 64.761 - 0.031 x	0.024	0.947

In comparison with provenances from four high temperature (mean annual maximum temperature >30.0 °C; mean annual minimum temperature >17.0 °C) areas in Australia, six low temperature (mean annual maximum temperature <30.0 °C; mean annual minimum temperature <17.0 °C) areas showed the fast germination rate and the high total germination percentage.

Early Seedling Growth Study on relationship between early seedling growth (Table 7) and some climatic factors (mean annual values) of the natural habitat of provenance in three watering levels.

We found, in control treatment, height growth of the seedling has been associated with intrinsically the driest quarter precipitation of the seed collection areas of provenance in Australia (Table 8). In all the treatments, length growth of the biggest leaf of the seedling was related to mean annual maximum temperature and mean annual minimum temperature in origin of provenance (Table 10). In water stress treatment, basal diameter growth of the seedling was related to mean annual minimum temperature of the seed collection areas; In addition, the driest quarter precipitation of the natural habitat of provenance can affect basal diameter growth of the seedling in severe drought treatment (25% of field capacity), and number of rainy days can promote its growth in control treatment (Table 9).

In contrast, there was no linear regression relationship between width rowth of the biggest leaf of the seedling and climatic factors in origin of provenace (Table 11).

CONCLUSION AND DISCUSSION

In the forest, when the seeds have surmounted the various hazards which attend their ripening, dispersal and dormancy phases, they are ready to germinate provided they encounter the appropriate environmental cues. Each species has its own characteristic set of germination requirements. The germination characteristics of seed are laid down during the course of its development, and it is not surprising to find that the environmental conditions experienced by the parent plant during seed maturation can strongly influence the degree and type of

germination in the seed (Akhtar 1973; Doran et al 1984).

Table 7. Values of early seedling growth characteristics (means and standard errors) *

Seedlot No.	Treatment	Height	Basal diameter(mm)	Length of the biggest leaf	Width of the biggest leaf(mm)
15070	25%	52.8(2.1)	3.6(0.1)	117.2(4.2)	20.5(0.6)
	50%	68.9(3.3) C	5.3(0.1) A	126.6(6.1) A	27.2(0.9) A
	100%	92.2(7.0)	6.9(0.2)	133.5(4.7)	23.4(0.7)
15073	25%	41.6(1.8)	4.2(0.1)	116.3(4.1)	25.9(0.9)
	50%	61.4(2.9) AC	5.5(0.1) A	156.0(4.9) AB	34.3(1.7) A
	100%	74.1(3.6)	8.3(0.3)	153.5(5.2)	38.4(2.3)
15074	25%	42.7(2.2)	4.2(0.1)	127.1(6.0)	26.7(0.8)
	50%	59.9(1.8) AC	5.7(0.1) A	142.2(4.9) ABC	30.0(1.5) A
	100%	72.6(4.1)	7.4(0.4)	164.3(5.3)	31.4(2.0)
15075	25%	31.4(1.5)	4.0(0.1)	98.6(5.6)	31.8(2.1)
	50%	51.9(2.4) AC	5.3(0.2) A	124.0(4.2) ABC	37.9(1.8) A
	100%	78.6(4.8)	8.2(0.4)	137.8(4.5)	38.7(2.0)
15076	25%	35.5(3.6)	4.3(0.2)	98.3(5.8)	29.7(2.2)
	50%	51.0(2.5) ABC	6.3(0.2) A	111.9(3.7) ABC	37.5(1.4) AB
	100%	78.3(4.9)	8.7(0.3)	120.9(4.1)	38.1(1.8)
15077	25%	51.5(2.4)	4.7(0.2)	96.3(5.4)	28.4(1.2)
	50%	65.0(3.1) ABC	6.0(0.2) A	124.9(5.9) ABC	34.9(1.5) AB
	100%	95.4(7.5)	9.4(0.7)	114.2(3.8)	33.7(1.0)
15081	25%	46.8(2.0)	4.3(0.1)	111.3(5.6)	28.9(1.0)
	50%	65.6(3.2) BCD	6.0(0.2) A	116.3(4.1) B	31.1(1.6) B
	100%	84.7(6.3)	7.7(0.7)	112.9(5.6)	27.3(1.8)
15084	25%	52.4(2.6)	4.7(0.2)	98.9(6.0)	26.8(0.9)
	50%	68.1(3.3) BD	7.4(0.5) A	115.4(4.3) ABC	26.1(0.8) B
	100%	107.1(8.6)	8.7(0.6)	128.4(4.2)	28.0(1.1)
15085	25%	54.4(3.1)	4.4(0.2)	89.7(5.1)	26.3(1.3) B
	50%	71.6(4.0) BD	6.0(0.2) A	107.3(4.3) BC	31.7(0.9)
	100%	92.4(7.1)	7.1(0.6)	98.2(5.9)	29.8(2.0)
15944	25%	49.3(2.3)	4.7(0.1)	106.5(4.5)	28.9(1.4)
	50%	56.0(3.4) D	5.1(0.2) A	105.9(4.7) DC	30.8(1.8) B
	100%	105.8(8.3)	10.5(0.7)	125.4(6.1)	38.3(1.9)

* Capital letters refer to differences detected between provenances. Values followed by the same letter are not significant at p 0.05

Table 8. Relationship between height growth and climatic factors in origin of provenance

Climatic factors	Treatment	Model	R	P
Rainfall(mm)	100%	h 80.045 + 0.019 x	0.330	0.352
	50%	h 65.403 + 0.008 x	0.244	0.498
	25%	h 45.028 + 0.002 x	0.053	0.885
The driest quarter precipitation (mm)	100%	h 72.500 + 0.368 x	0.908	0.001 **
	50%	h 59.008 + 0.070 x	0.284	0.427
	25%	h 39.297 + 0.154 x	0.603	0.065
Maximum temperaturez (°C)	100%	h 151.677 - 2.114 x	0.630	0.055
	50%	h 83.198 - 0.705 x	0.375	0.286
	25%	h 78.845 - 1.097 x	0.529	0.116
Minimum temperature(°C)	100%	h 121.677 - 2.127 X	0.522	0.122
	50%	h 72.410 - 0.660 x	0.283	0.428
	25%	h 60.670 - 0.939 x	0.365	0.299
Number of rainy days	100%	h 68.017 + 0.434 x	0.551	0.098
	50%	h 64.235 + 0.049 x	0.108	0.767
	25%	h 39.779 + 0.131 x	0.264	0.461

Table 9. Relationship between basal diameter growth and climatic factors in origin of provenance

Climatic	Treatment	Model	R	P
Rainfall(mm)	100%	d 7.160 + 0.003 x	0.527	0.117
	50%	d 6.299 + 0.001 x	0.326	0.357
	25%	d 4.137 + 0.001 x	0.243	0.500
The driest quarter precipitation(mm)	100%	d 7.431 + 0.020 x	0.572	0.084
	50%	d 5.517 + 0.008 x	0.385	0.272
	25%	d 3.942 + 0.009 x	0.741	0.014 *
Maximum temperature (°C)	100%	d 9.807 - 0.050 x	0.173	0.632
	50%	d 8.437 - 0.085 x	0.484	0.156
	25%	d 5.965 - 0.055 x	0.567	0.087
Minimum temperature (°C)	100%	d 9.739 - 0.091 X	0.255	0.477
	50%	d 8.233 - 0.150 x	0.686	0.029 *
	25%	d 5.604 - 0.082 x	0.682	0.030 *
Number of rainy days	100%	d 6.280 + 0.044 x	0.629	0.049 *
	50%	d 6.247 + 0.008 x	0.192	0.594
	25%	d 3.825 + 0.011 x	0.453	0.188

Table 10. Relationship between lenght growth of the biggest leaf and climatic factirs in origin of provenance

Climatic factors	Treat ment	Model	R	P
Rainfall(mm)	100%	l = 115.011 +0.032 x	0.361	0.306
	50%	l = 123.785 +0.002 x	0.023	0.949
	25%	l = 97.533 +0.020 x	0.368	0.296
The driest quarter	100%	l = 144.519 - 0.367 x	0.577	0.081
precipitation(mm)	50%	l = 138.407 - 0.361 x	0.564	0.083
	25%	l = 113.042 - 0.166 x	0.436	0.208
Maximum	100%	l = 10.734 + 4.644 x	0.897	0.001 **
temperature (°C)	50%	l = 14.289 + 3.617 x	0.868	0.001 **
	25%	l = 37.591 + 2.275 x	0.736	0.015 *
Minimum	100%	l = 44.670 + 5.339 X	0.833	0.003 **
temperature(°C)	50%	l = 65.916 + 3.621 x	0.701	0.024 *
	25%	l = 56.734 + 3.122 x	0.815	0.004 **
Number of	100%	l =123.202 +0.123 x	0.100	0.784
rainy days	50%	l =134.878 + 0.055 x	0.256	0.476
	25%	l =100.001 + 0.130 x	0.175	0.629

Table 11. Relationship between width growth of the biggest leaf and climatic factors in origin of provenance

Climatic factors	Treatment	Model	R	P
Rainfall(mm)	100%	w =29.771 +0.007 x	0.270	0.451
	50%	w =34.723 +0.001 x	0.326	0.358
	25%	w =27.236 +0.001 x	0.018	0.960
The driest quarter	100%	w =33.920 -0.028 x	0.156	0.666
precipitation(mm)	50%	w =34.597 -0.057 x	0.442	0.201
	25%	w =26.716 -0.015 x	0.153	0.673
Maximum	100%	w =22.042 +0.355 x	0.242	0.500
temperature()	50%	w = 26.545 + 0.187 x	0.178	0.624
	25%	w = 31.820 + 0.009 x	0.190	0.598
Minimum	100%	w = 29.838 + 0.183 X	0.101	0.782
temperature(C)	50%	w = 32.453 + 0.018 x	0.014	0.970
	25%	w = 32.817 + 0.001 x	0.358	0.310
Number of	100%	w = 29.674 + 0.066 x	0.187	0.604
rainy days	50%	w = 27.875 + 0.010 x	0.395	0.259
	25%	w = 26.892 + 0.010 x	0.052	0.887

In comparison with provenances of *E. microtheca* from four high temperature (mean annual maximum temperature >30.0 °C; mean annual minimum temperature >17.0 °C) areas in Australia, six low temperature (mean annual maximum temperature <30 °C; mean annual minimum temperature <17.0 °C) areas showed the fast germination rate and the high total germination percentage. It implied that climatic variations between different origin of provance in mean annual maximum temperature and mean annual minimum temperature were main climatic factors to affect seed germination quality. the same conclusion was reached by Doran et al. (1984). However, according to Ladiges (1974), genetic variation was observed among a series of *E. viminalis* populations whose habitats range from wet to dry climates. In comparison with populations from low-rainfall areas, two high-rainfall populations showed rapid germination and fast early seedling growth. To some extent, these results were similar, because it is plausible that temperature (mean annual maximum temperature and mean annual minimum temperature) and mean annual precipitation are highly correlated, they could affect together air humidity and surface soil moisture of the seed collection areas.

Possible causes of the complex mosaic patterns of distribution of eucalyptus species in Australia have been examined in relation to the natural habitat condition. Differences in drought resistance and tissue water relations have also been observed among provenances with a species (Ladiges 1974, 1975; Grunwald et al 1982). These differences may help to explain adaptations of species and provenances to specific sites. An investigation of seed germination and early seedling growth response of *E. microtheca* was based on seeds collected from 10 widely-separated provenances. The study demonstrated that genetic variation of seed germination and early seedling growth were observed among a series of *E. microtheca* provenances whose natural habitats range from different climatic conditions in Australia. In ten provances, both the model of seed relative germination percentage and the model of seed total germination percentage fitted Logistic regression [$y=a/(1+exp(-cx+b))$]. In control treatment, height growth of the seedling has been associated with intrinsically the driest quarter precipitation of the seed collection areas. In all treatments, length growth of the biggest leaf of the seedling was related to mean annual maximum temperature and mean annual minimum temperature in origin of provenance. Basal diameter growth of the seedling was related to mean annual minimum temperature of the natural habitat in water stress treatment. The similar results have also been reported in growth of 16 provenances of *E. microtheca* in a regularly irrigated plantation in eastern Kenya (Johansson et al 1996).

In the light of the natural distribution of *E. microtheca* and seed collection localities used in the seed germination and early seedling growth studies, it can be concluded that the north-western Australian seeds of *E. microtheca* exhibited the slow germination rate and the low total germination percentage and the slow early seedling growth which may be related to their hotter and drier natural habitats. The south-eastern Australian seeds of *E. microtheca* exhibited the fast germination rate and the high total germination percentage and the rapid early seedling growth which may be related to their cooler natural habitats and evenly distrbuted annual rainfall. From an ecological viewpoint, the fast germina-

tion rate and the high total percentage germination of the seed and rapid growth of the seedling appear to be favourable adaptations to the climatic conditions prevailing in the natural habitat of the provenance.

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